# NATICK SOLDIER CENTER

## Natick Soldier Center View


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**Research Scientist**



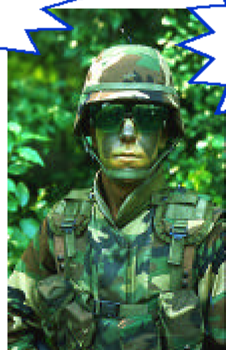
The U.S. Army Soldier and Biological Chemical Command

# Natick Soldier Center Mission

***RDT&E to Maximize the Soldier's Survivability, Sustainability, Mobility, Combat Effectiveness and Quality of Life by Treating the Soldier as a System***

Reliance 3 S&T

Human Systems DTA



**Clothing & Individual Equipment**

***Soldier System Technologies Integration***

Warrior Systems TBESC

JTAG

**Personnel & Cargo Airdrop**

DOD Combat Feeding Program

**Combat Rations & Field Feeding**

JOCOTAS

**Shelters & Field Services**

## *Adding Value Through:*

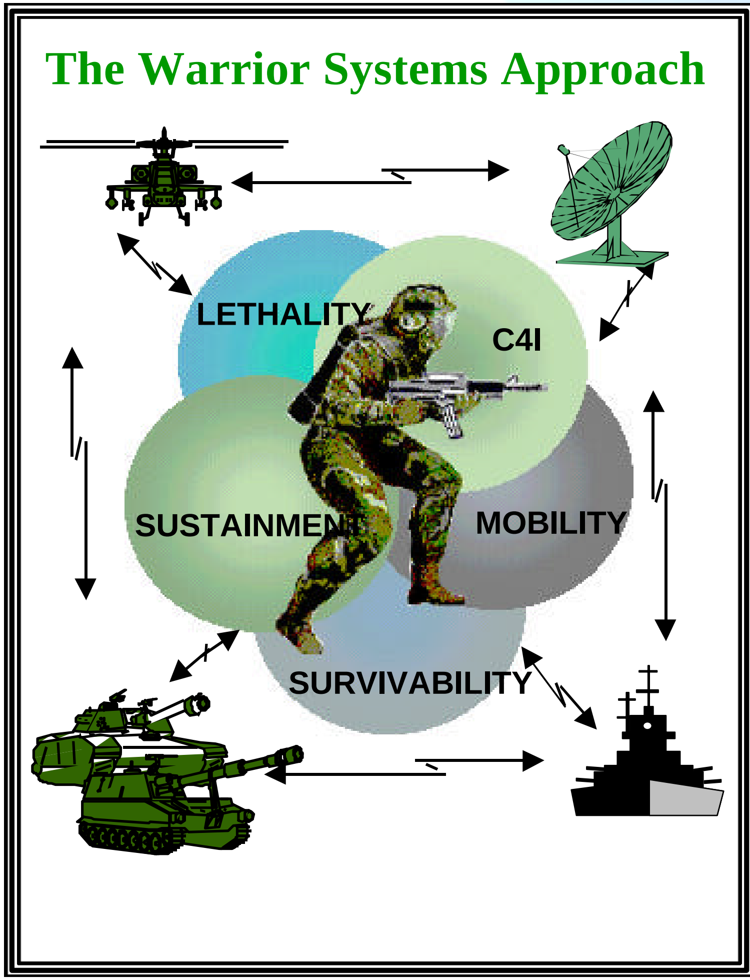
- **Technology Generation & Application**
- **Soldier Systems Integration**
- **Solving Field Problems**

# Our Mission

***Plan, organize, direct, and conduct RD&E for the Army and other services to...***

- ***Maximize the individual warrior***
  - **Survivability**
  - **Sustainability**
  - **Mobility**
  - **Combat Effectiveness**
  - **Quality of Life**
- ***Treat the warrior as a system***

# The Warrior as a System




"Fundamentally Different - Exponentially Better"

*Survivability,*

*Sustainability, and Mobility...*

*...Integrated with Lethality and C4I*

*...The Foundation for all Warrior System Components*

***The Warrior System Platform***

# Systems Integration

## FUTURE OPERATIONAL

- Digitized soldier
- Enhanced situational awareness
- Enhanced target acquisition
- Enhanced protection
- Enhanced communication integrated navigation

## TECHNOLOGY BARRIERS

- High Density Power
- Miniaturization
- Human Systems Integration

## PACING TECHNOLOGIES

- Microelectronics
- Improved lightweight sensors
- Advanced materials
- High resolution flat panel displays

ARIEM

ARL-HRED

# The Soldier of 2025

" If we are really good, and we are, the soldier of 2025 will be as effective as the tank of 1995. "


– ***LTG Paul Kern***
*Military Deputy Director, Army Acquisition Corps*
*October 1997*

# Mosher's Work at General Electric …1960s

THE ACTUATOR SUBSYSTEM 173

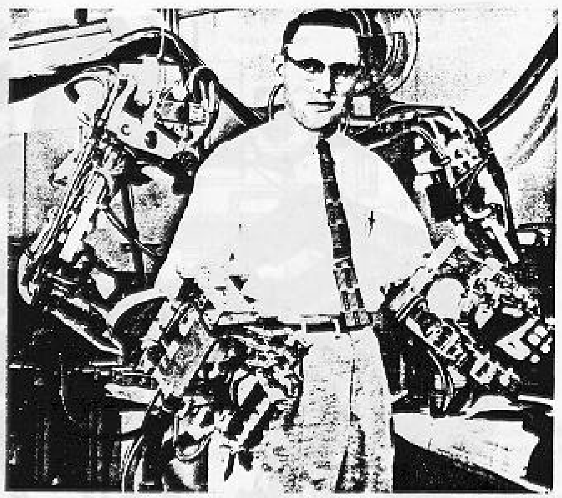


FIGURE 96.—The Handyman master station, with ten bilateral servos in each arm-hand combination. (See also fig. 98.) (Courtesy of R. S. Mosher, General Electric Co.)

THE ACTUATOR SUBSYSTEM 181

FIGURE 102.—The balance machine built by General Electric for the Army Tank and Automotive Center (ATAC). Man's ability to balance a two-legged walking machine was demonstrated with this machine. (Courtesy of R. S. Mosher, General Electric Co.)

178 TELEOPERATORS AND HUMAN AUGMENTATION

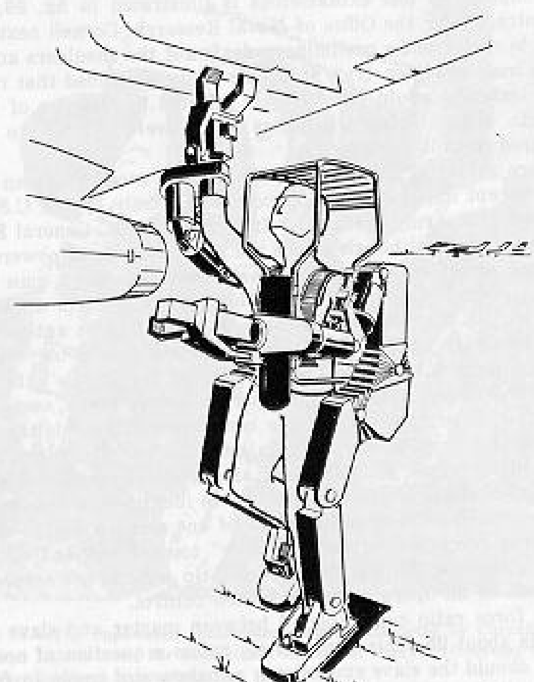


FIGURE 100.—Sketch of the General Electric powered exoskeleton concept (Hardiman I) (ref. 87).

# Cornell Aeronautical Laboratory … 1960s

176 TELEOPERATORS AND HUMAN AUGMENTATION

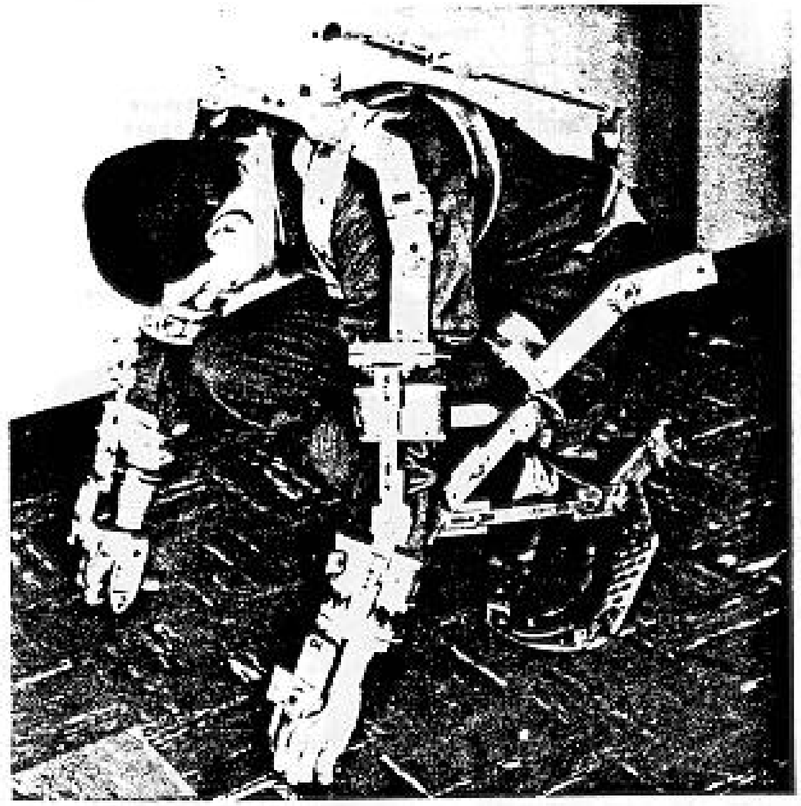
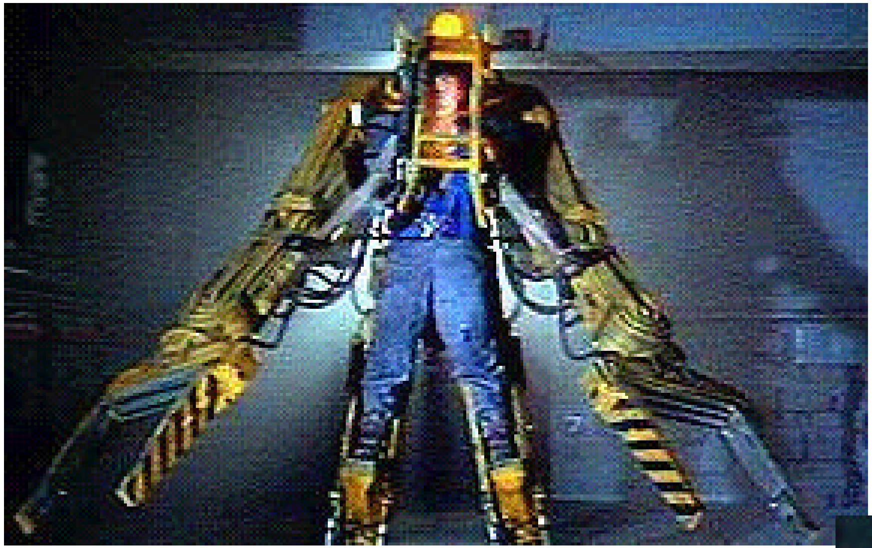
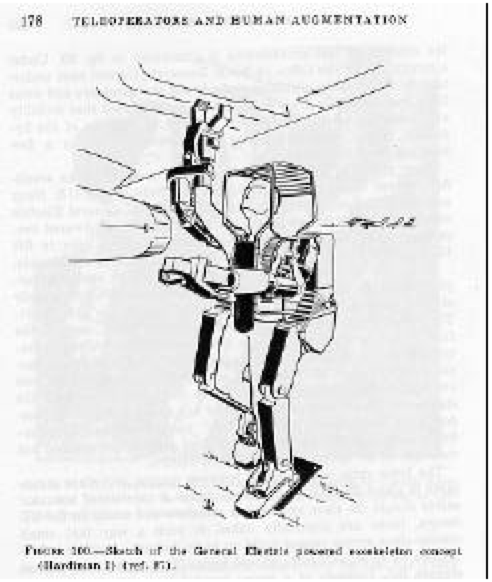


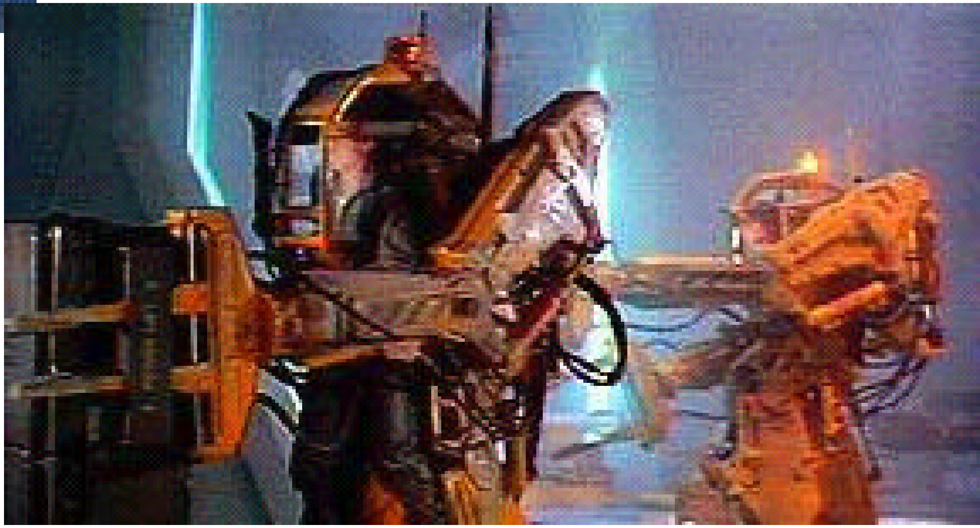
FIGURE 99.—The unpowered exoskeleton model constructed by Cornell Aeronautical Laboratories for exoskeleton structural studies. (Courtesy of Cornell Aeronautical Laboratory.)

# Powerloader From the 1986 movie Aliens






**Powerloader was made of plastic, but note the similar appearance to Mosher’s 1960’s sketch.**

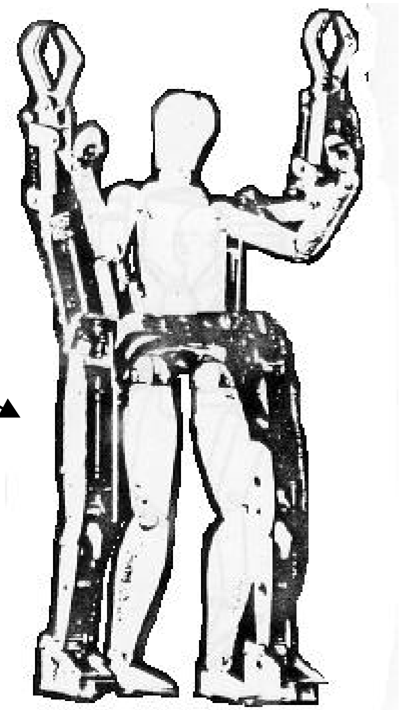


# Prototypes Developed in the 1960s

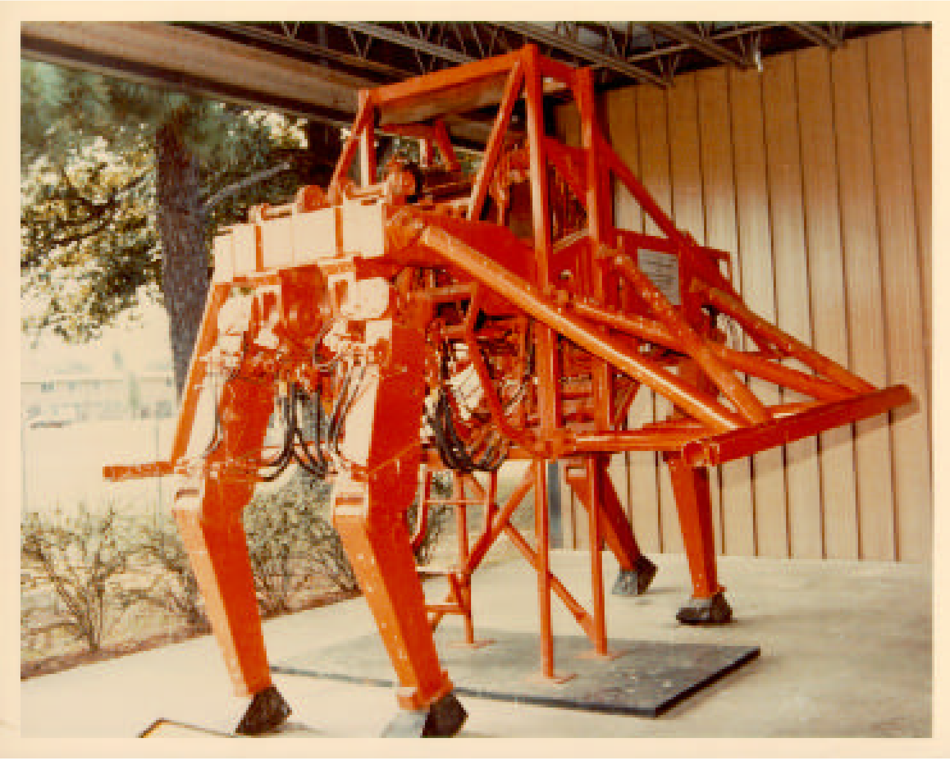
**Built by GE R&D Center**
**Based on Ideas from Cornell Aeronautical Laboratories**

**Army Funded Device**
**Based on Mosher's Ideas**

Lifted 1,500 lbs while user exerted about 40 lbs



Hardiman, built for the Navy by the General Electric Research and Development Center, Schenectady, NY, functioned as a human forklift.



# Moore's Concept
# Los Alamos … 1980s

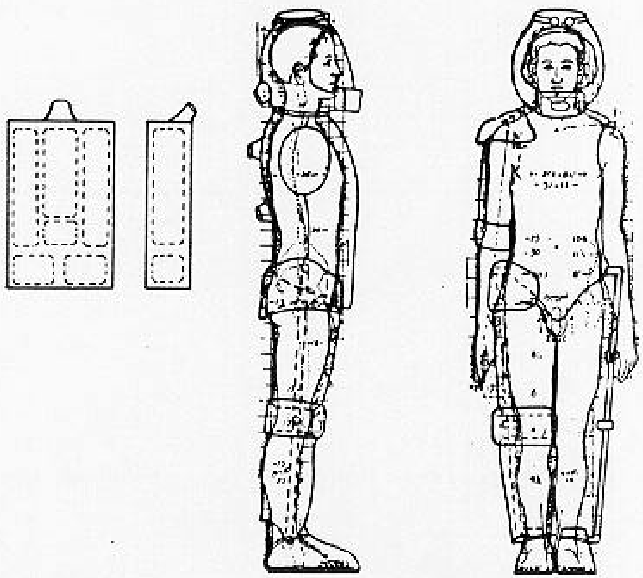
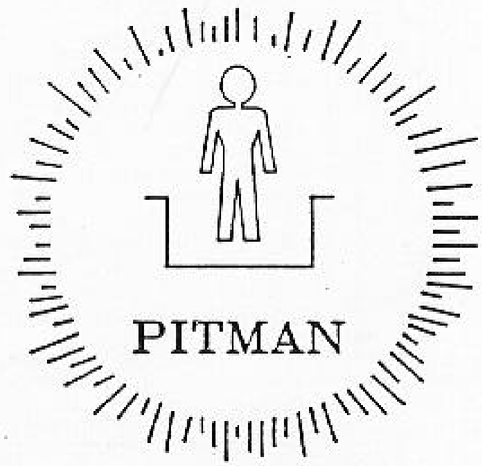


Fig. 9. Robotic Armor Suit.

PITMAN

A Powered Exoskeletal Suit
for the Infantryman




A System Description
and
Research and Development Plan

Submitted by
Jeffrey A. Moore
Project Leader

January 1988

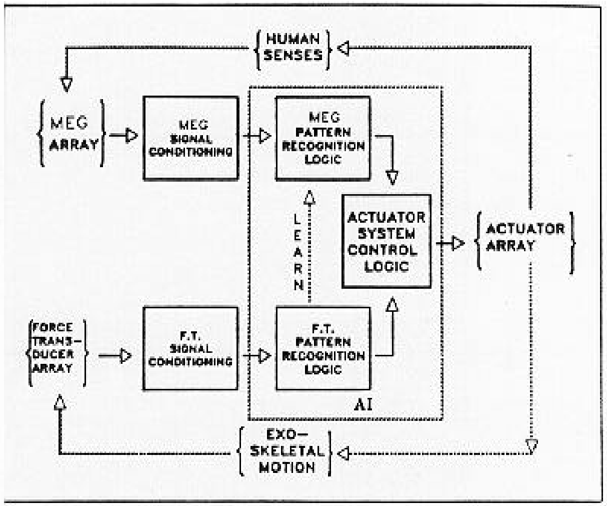



Fig. 6. Control System Logic.

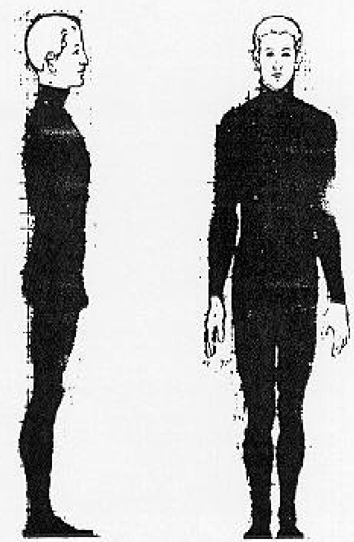


Fig. 7. Body Suit.

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# More Detailed View of Pitman


Figure 8. Pitman Concept

# Prof. Kazerooni's Work at Univ. Calif. Berkeley … 1990-present

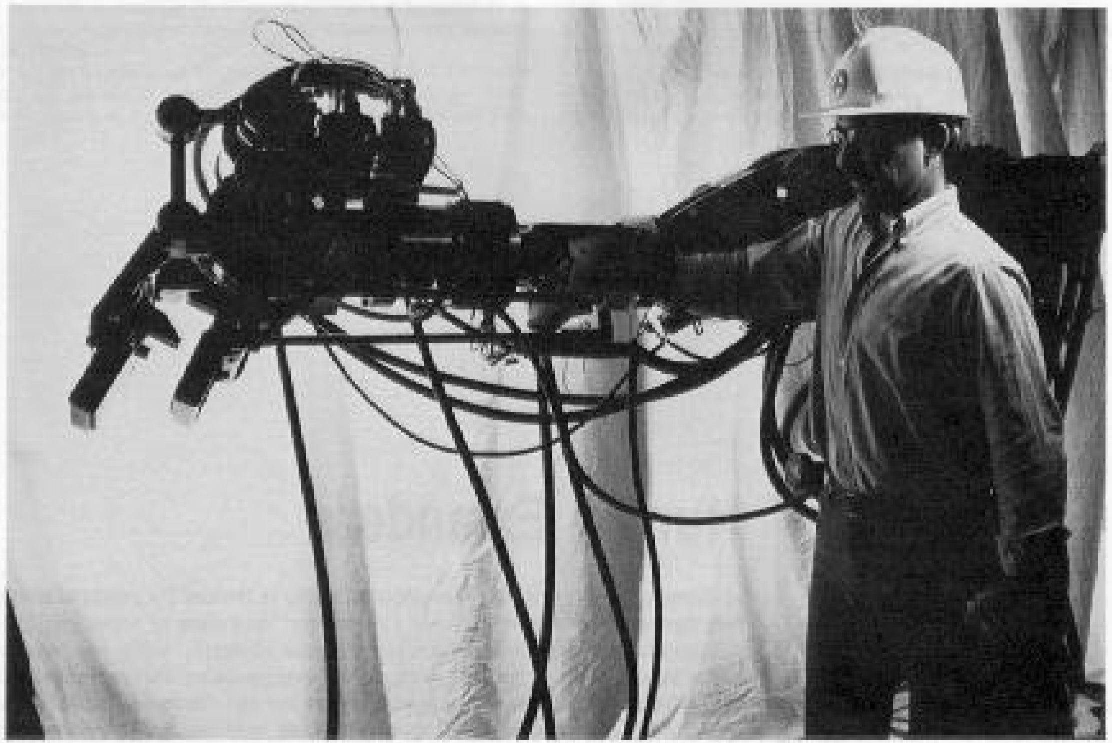


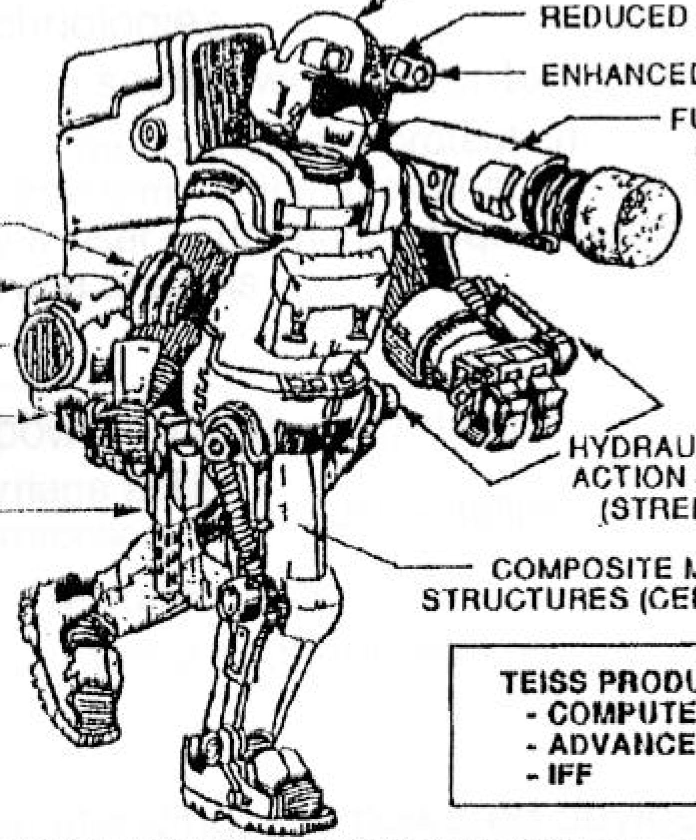
Fig. 1 Experimental six-degree-of-freedom hydraulic extender

Army Research Laboratory

# Warrior's Edge Focus • Mobility Enhancement

**INCREASED SURVIVABILITY, IMPROVED LETHALITY, INTEGRATED C³, OPTIMIZED SUSTAINABILITY**

**TEISS P3I SOLDIER**




**TEISS PRODUCT INTEGRATION**
- COMPUTER
- ADVANCED UNIFORM • CB DEF
- IFF

## Bernard Corona ...

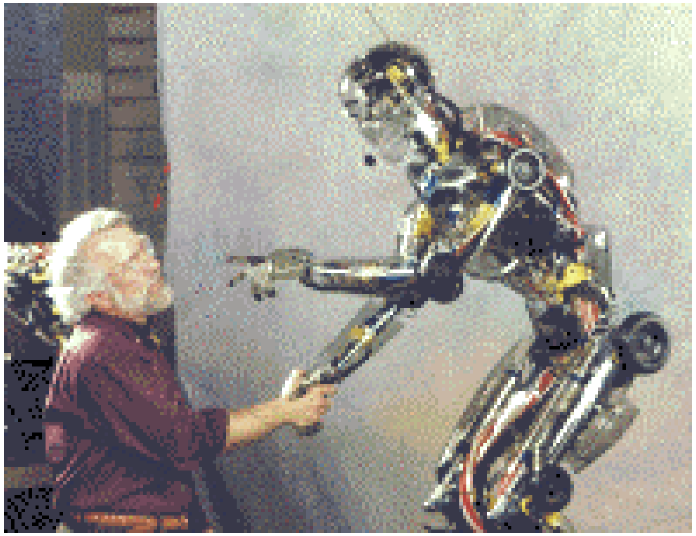
## 1980-90s

| ALL DIRECTORATES | RDECS | PM SOLDIER | UNIVERSITIES | OTHER |
|---|---|---|---|---|
| HRE. MD. S3I. SD. EPS. ACIS | NRDEC ARDEC MICOM CECOM | TRADOC BTLLB SOCOM | U of UTAH, U of C. BERKLEY, U OF PENN, MIT, HARVARD } ARO | INDUSTRY USMC DARPA DOE PNWL & ONL |

WE MOBILITY 92 (i)

# Sarcos

**is very Active in Many Augmentation Relevant Areas**



# Battelle
# Pacific Northwest Laboratory

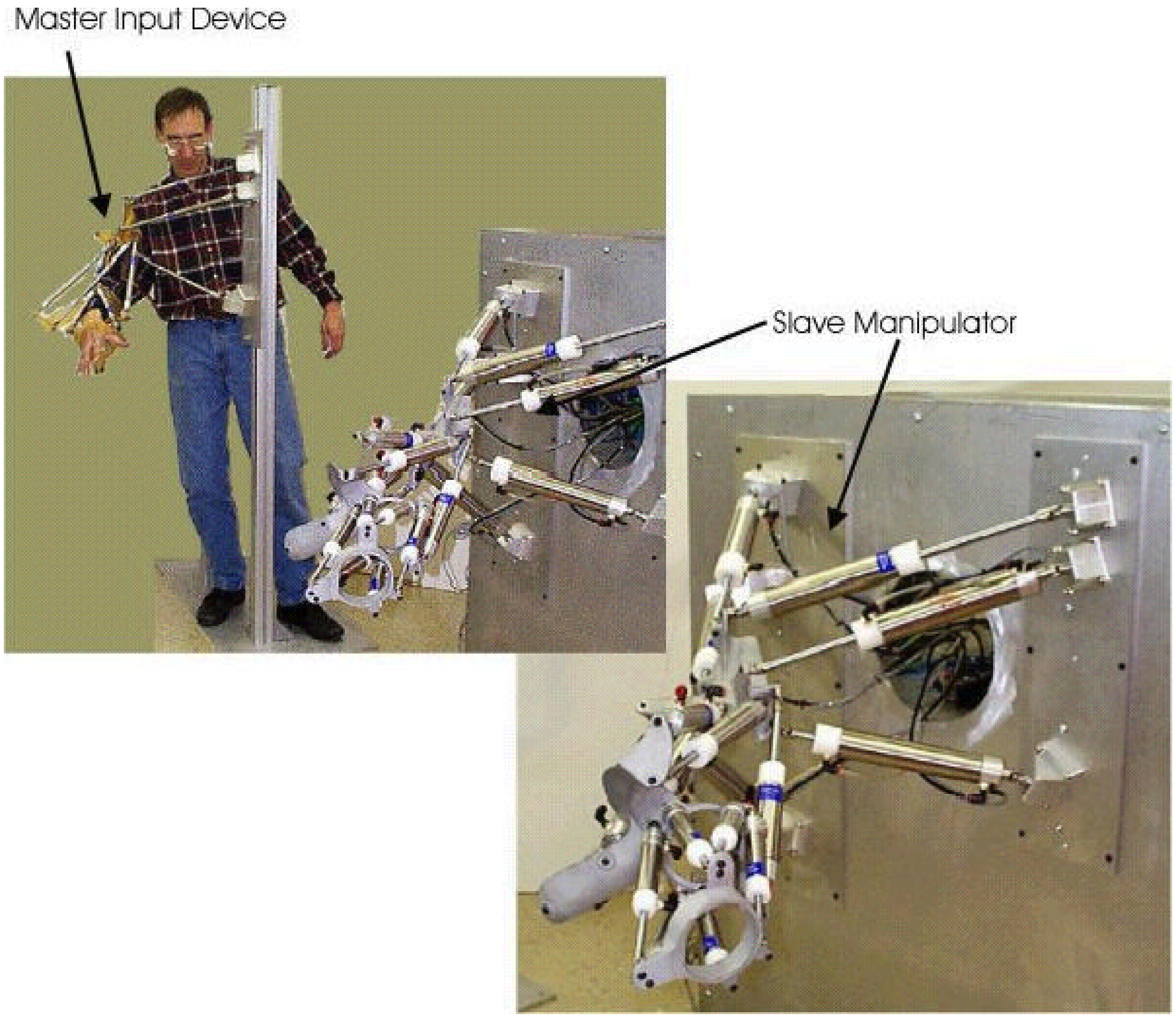
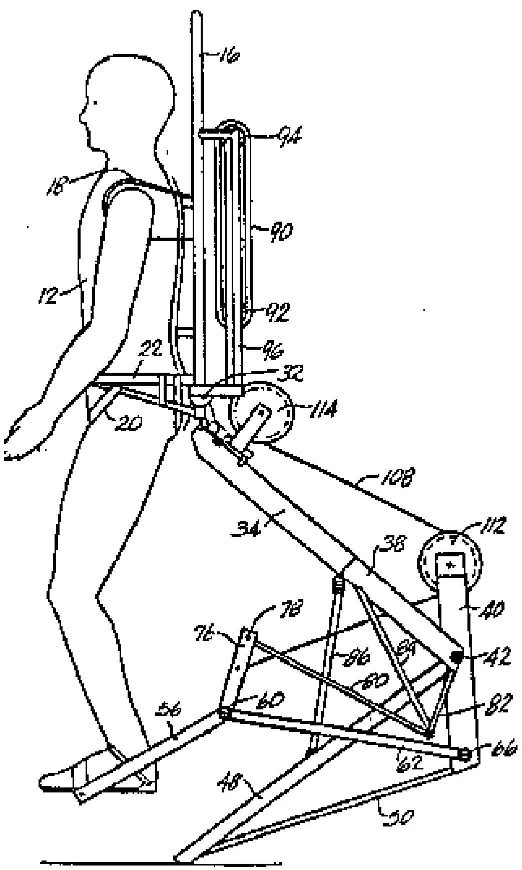


Fig. 2

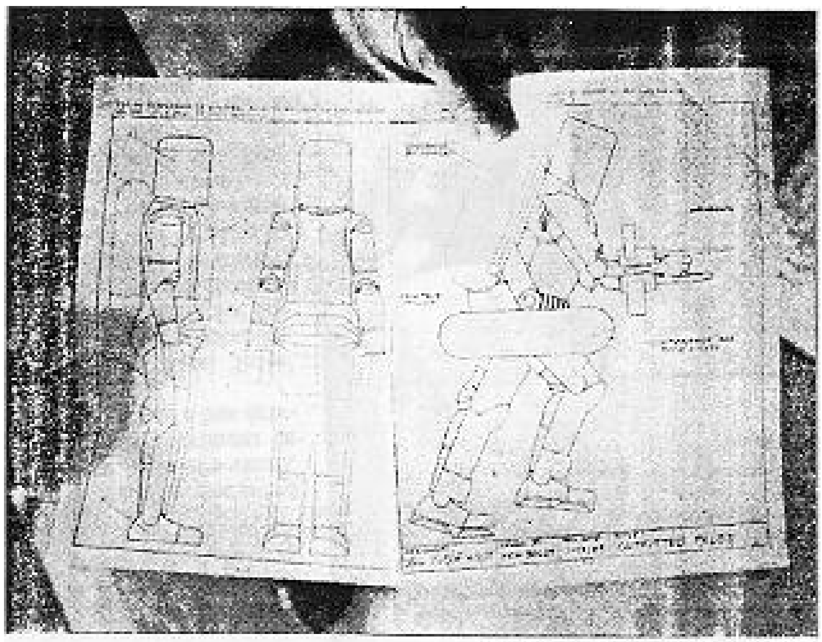



Artist's Rendering


# John Dick's Springwalker (Applied Motion Inc.) ……1990s

# Boldt's Talos

- Began in the Late 1980's as Walking Aid for Paraplegics
- Formed 2-person Company Schuger … 1990



The Philadelphia Inquirer / RON TARVER

**Some of the early plans** for the Boldts' robotic soldier are displayed by Ken Boldt. The designs have since been updated.

The Philadelphia Inquirer / RON TARVER

**Ken Boldt** works on TALOS, part of which hangs next to him, with his wife, Joyce. They're hoping the military will be interested.

# Example of Passive "Exo" Device

# Army S&T Objective

## IV.G14 Load Carriage Optimization for Enhanced Warfighter Performance

### 1. Problem:
• Load carriage gear requires design improvements in order to enhance the mobility of ground troops.

### 2. Barriers:
•Absence of detailed biomechanical data, design principles and validated models of human movement to design load carriage equipment that optimizes soldier performance

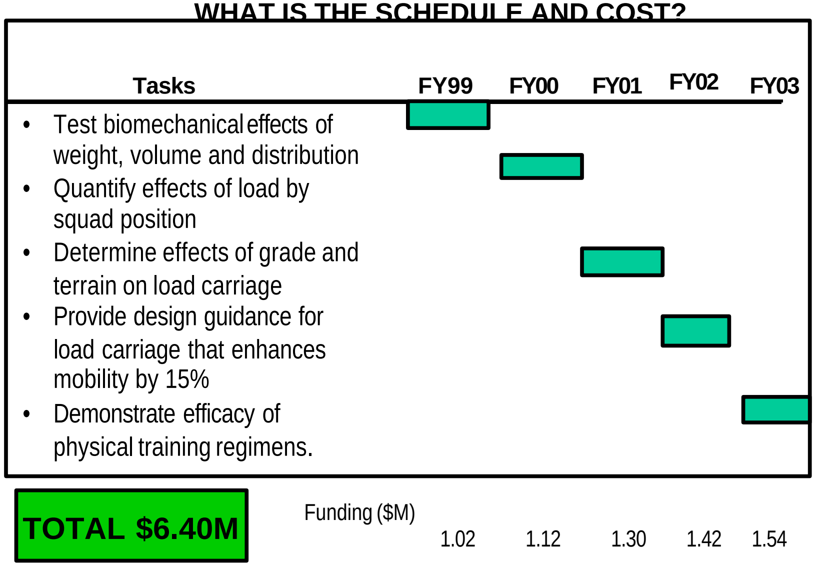
### 3. Overcoming the Barriers:
• Develop robust biomechanical methods to evaluate the variables (load, volume, terrain, grade, fatigue) that affect soldier mobility.
• Create physics based model of human locomotion for analyzing new or untested values of critical variables.

### 4. Capabilities:
•Improved soldier combat performance through enhanced mobility and reduced fatigue

### •5. Products/Transitions:
•Methodology for measuring the forces that act on the human body during movement
•Biomechanical data and physics- based models of human locomotion for simulating load carriage and improved design of load carriage equipment for the PM-SDR and MC.

### 6. Quantitative Metric:
•Data, principles, training regimens and guidance to equipment designers for load carriage gear that enhances mobility across squad positions by 15%.
•Quantitative model to design load carriage gear with reductions in cost/schedule through simulation and analysis.

### WHAT IS THE SCHEDULE AND COST?




### 7. Warfighter Payoff:
•Load carriage gear that enhances mobility by 15% and "functionally" lightens the soldier's load without eliminating critical equipment from sustainment or combat loads.

### 8 Transition Milestones
•Provide empirically-based design principles and physics based model to equipment developers by FY03.

### 9. Endorsements:
•COL Stone, DCD, USAIC

### 10. Non-Army Funding:
•Strong Marine Corps interest.
•Leveraging expertise at HRED, Queens University, and Liberty Mutual Research.
• Agreed to exchange NSC-USARIEM biomechanics data with Boston Dynamics Institute for "Digital Biomechanics Lab". from their Phase II SBIR.

# IV.G.14 Load Carriage Optimization For Enhanced Warfighter Performance - A Joint SBCCOM-USARIEM Program

**Laboratory Successes** | **Lead To** | **Battlefield Success**


Data
Design principles
Physics-based model of human locomotion
Physical Training regimens

**Produce**

Load Carriage Gear that enhances troop mobility by reducing energy expenditure and extending endurance.

# Current Work Under Load Carriage Optimization STO

- Experimentally Examining Effect of Backpack Design [Weight, Load Distribution and Volume] on Soldier's Gait, Mobility, and Energy Expenditure

- Developed User Friendly Program to Examine Effect of Different Backpack Packing Methods on Dynamic Properties

- Using Passive Dynamics Analysis to Predict Effect of Backpack Design and to Create Model for Human Walking

- CRADA with Boston Dynamics Inc. (They have an SBIR in Modeling Human Motion)

# Concluding Remarks

- The Idea of Exoskeletons for Human Augmentation has a Long, Rich History

- The Implementation of This Idea offers Exciting, Long Range Possibilities

- This Goal and The Current Work At NSC to Improve The Soldier's Mobility, and Load Carriage Capability Have in Common The Need for:
    1) Physics Based Models of Human Motion
    2) Predictive Models for Human-Equipment Interaction
    3) Strong Links Between Experiment and Theory To Determine Benefits Associated with Engineering Changes